Incorporating data into grazing management decisions: supporting farmer learning

Short Title: Incorporating data into grazing management

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Abstract. Pasture consumption is an important contributor to farm business profitability in pasture based dairy systems around the world, including Tasmania. Research, development and extension prioritizes further increasing pasture consumption in the Tasmanian dairy industry, through progressing technical innovations and providing services to support increased farmer adoption of proven practices. Increasing farmer adoption of best practice grazing management recommendations relies on the continued development of extension delivery to meet farmer information and skill development needs. A social research study identified some of these needs by exploring pasture management approaches and associated learning processes of farmers whose practices were more versus less aligned to recommended practices. The aim was to improve understanding of the grazing management learning process and implications for extension in the context of data made available through new technology. Qualitative interview data revealed that pasture managers whose practices are more closely aligned to recommended practices have used pasture measurement tools and carried out associated calculations intensively for an extended period (≥ 1 year), before adapting best practices to suit their farm management approach. Less aligned pasture managers were aware of the importance of grazing management, but were less aware they lacked knowledge and skills required to implement recommended practices. The data suggest there is 'unconscious incompetence' at play, and that these farmers had not engaged in a supported learning process. These findings suggest that introducing innovative ways to acquire pasture growth data will not result in practice change unless dairy farmers have progressed through the grazing management learning process and come to understand how to use data effectively.

Keywords

Dairying, Extension: innovation, Farmer Adoption, Grazing Management, Pasture Utilization

Introduction

Improving grazing management practices is a key contributor to increasing pasture consumption and unlocking further business potential in pasture based dairy systems internationally (Maher and Bogue 2018). Maximizing high quality pasture consumption relies on farmers adopting

and adapting proven grazing management practices. Proven practices are knowledge-intensive; requiring farmers to understand underlying biological principles, carry out associated mathematical calculations and develop new on-farm skills. Recent New Zealand and Tasmanian research has found substantial farm income increases from using pasture growth data in grazing management decisions (Beukes *et al*. 2018; Irvine and Turner 2018) and technological innovations that capture pasture growth data more efficiently continue to be developed (Eastwood and Kenny 2009; Dairy Australia 2017).

Farmer adoption or adaptation of new technologies can be assisted through learning activities including extension (Cliffe et al. 2016). Robinson (1974) suggests a learning process that develops competency from 'unconscious incompetence' to conscious incompetence (becoming aware of a need for greater knowledge and skill development), to conscious competence (for example, through participating in learning through extension) to unconscious competence with the capacity to independently adapt recommended practices. These stages have resonated with farmers using a variety of decision making approaches, including rule of thumb, heuristic-based and a more quantitative approach (Ohlmer *et al*. 1998). Farmer engagement with extension and extent of adoption are influenced by values, motivations and attitude towards risk (Marra, Pannell and Ghadim 2003; Rodriguez *et al.* 2009). Some studies have considered tailoring extension by segmenting farmers according to farming styles (Waters, Thomson and Nettle 2009) or preferred learning styles (Kilpatrick and Johns 2003).

Biological principles underpinning recommended practices include seasonal effects on leaf emergence rate (Cooper 1964), how grazing at different leaf stages influences pasture productivity, quality and persistence (Fulkerson and Donaghy 2001), and the relationship between milk production and cow nutritional requirements (National Research Council 2001). Farmers also need practical skills including how to accurately assess leaf stage in the paddock and reliably use a pasture measurement tool. They must utilize this knowledge and information collected to make effective decisions on day-to-day grazing allocations and supplementation as well as forward planning feed budgets.

Regularly measuring pasture growth across the milking platform using a tool such as a plate meter quantifies the amount of pasture available for grazing at a paddock and farm level (O'Donovan *et al*. 2002). Advice is that these data be collected weekly or fortnightly to maximize ongoing accuracy of allocation calculations and therefore consumption of available pasture (Pasture Plus 2006). In reality, there is a tendency for experienced farmers to alternate between measuring pasture growth with a tool and visually assessing pasture growth, with quantification carried out at seasonal key points, or to 're-calibrate' visual assessments (Eastwood and Kenny 2009). Turner and Irvine (2017) propose that a significant period of supported knowledge and skill development is likely to have occurred before farmers advance to adapting measuring and monitoring pasture in their grazing management.

The time and effort required to measure pasture using traditional tools limits farmer adoption of practices known to improve pasture management and consumption (Craigie 2013). A recent survey of Tasmanian dairy farmers indicates that 57% have not learned how to accurately quantify pasture growth through intensive measurement tool use (Hall *et al*. 2017), and are therefore unlikely to use a data-based approach to grazing management. This study explored differences in pasture management approaches and associated learning processes among Tasmanian dairy farmers. The aim was to improve understanding of grazing management learning process and implications for extension in the context of data available through new technologies (e.g. satellite imagery and drone sensors). It addresses the research question: How do dairy farmers develop the knowledge and skills required to adopt or adapt recommended pasture management practices in the context of data made available through new technology?

Methods

A qualitative design, appropriate to the exploratory nature of the research was chosen to provide rich descriptive insights into farmer learning processes (Lincoln and Guba 1985). Data were collected from 14 dairy farm owners or managers in northern Tasmania through semi-structured, in-depth interviews. The sample was divided equally between pasture managers whose practices were closely aligned to recommended practices (termed more aligned) and less closely aligned pasture

managers (termed less aligned). Participants were selected and recruited through their voluntary participation in research, development and extension (RD&E) activities carried out by the Tasmanian Institute of Agriculture (TIA). TIA extension staff identified potential members of the more aligned cohort, selecting 7 Tasmanian dairy farmers known to use recommended grazing management principles and operate within the top 10% of the industry in relation to pasture consumption. The 7 members of the less aligned cohort were selected from dairy farmers enrolled in a coaching program that delivered foundational pasture management training. Interviews were conducted between October 2015 and November 2016, prior to the less aligned pasture managers engaging in coaching. Participating farmers managed medium-to-large scale dairy farms (average 625 cows). The research was approved by the UTAS Social Science Ethics Committee (H0015305).

Interview questions were open-ended with prompts to elicit fuller responses from participants. Questions focused on farmers' approach to grazing management: its importance in the farm business, participation in related extension and learning activities, knowledge and skill development, and pasture measurement data's role in decision making. The study's scope was limited to how farmers develop pasture management knowledge and skills and therefore interviews did not seek to quantify or compare farm business metrics, or conduct farmer segmentation analysis. Interviews averaged 51 minutes in length, and digitally recorded for subsequent transcription and thematic analysis. A combined inductive and deductive thematic analysis of interviews generated manually coded themes from the data (Lincoln and Guba 1985, Ryan and Bernard 2000). Themes were shaped by the research question and literature (Huberman and Miles 1994, Ryan and Bernard 2000).

Results

Important similarities in the way dairy farmers approached grazing management were apparent, regardless of the extent they applied best practice principles. The view that grazing management is an essential contributor to successful dairy farming was consistent across more aligned and less aligned cohorts, as was **r**egular (i.e. 4+ times per year) engagement in public extension activities. All respondents described a rotational grazing system approach using visual

assessments of pasture covers, the 'readiness' of paddocks to be grazed and condition of pasture remaining following grazing. Through engagement in extension activities and learning from other farmers, interviewees in both groups were aware of optimal pre- and post-grazing pasture biomass, and of leaf stage 'rules of thumb' for setting rotation length that are consistently communicated within the Tasmanian dairy industry.

The extent of measuring pasture growth with a tool varied within each farmer cohort, and varied from no use to regular use among less aligned farmers. Measuring pasture was more common among more aligned grazing managers, as was quantifying feed allocations (i.e. numeric calculations) and applying leaf stage in grazing rotation planning (in addition to being aware of it; Table 1). Only 2 of the 7 farmers in the more aligned cohort currently use data intensively in their grazing management, through tight leaf stage based rotation planning, tight quantification of allocations, and regular measurement of pasture growth using a tool. However, all more aligned pasture managers have accumulated the knowledge and skills to use a combination of practices and confidently apply grazing management principles in a responsive manner. More Aligned Farmer 5 explained that his confident grazing management relies on knowledge developed through an intensive learning process. High pasture consumption is therefore achievable because, "I know how much is in a paddock, and I know how much the cows need, and I know how much is going to be left behind. Or whether they haven't had enough."

Table 1. Characteristics of learning and practices associated with grazing management, from More Aligned and Less Aligned farmer cohorts.

Farmers	Extension Engagement	Intensive Learning	Visual Assessments	Leaf Stage Rotation	Quantify Allocations	Current Tool Measurements	Adapt Principles
More Aligned							
1	Regularly	Yes	Yes	Tightly	Tightly	Regularly	Yes
2	Regularly	Yes	Yes	Tightly	Tightly	Occasionally	Yes
3	Occasionally	Yes	Yes	Loosely	Tightly	Occasionally	Yes
4	Occasionally	No	Yes	Loosely	Loosely	Rarely	Yes
5	Regularly	Yes	Yes	Loosely	Tightly	Regularly	Yes
6	Regularly	Yes	Yes	Tightly	Tightly	Occasionally	Yes
7	Regularly	Yes	Yes	Tightly	Tightly	Regularly	Yes
Less Aligned							
1	Regularly	No	Yes	No	No	No	No
2	Regularly	No	Yes	No	No	Rarely	No
3	Regularly	No	Yes	Loosely	Loosely	Rarely	No
4	Regularly	No	Yes	Loosely	Loosely	No	No
5	Rarely	No	Yes	No	No	No	No
6	Regularly	No	Yes	No	Loosely	Occasionally	No
7	Regularly	No	Yes	Loosely	Tightly	Regularly	Yes

The capacity of more aligned grazing managers developed through previous learning processes that involved consistent measuring and monitoring of pasture growth over a period of at least one year, and for all but one self-taught farmer, consistent support from advisory services (either through public extension or private consultancy) throughout that period. New knowledge and skills combined with on-farm experience and observation, and led to capacity to adapt recommended practices to suit individual approaches and farm contexts. More Aligned Farmer 7 made the important distinction between the ability to take pasture growth measurements, and the capacity to utilize measurement data to fine tune grazing management decisions, commenting that, “Understanding what to do with that information is the hard thing. I think for someone to actually make the change [to more aligned grazing management] they probably need to stick with it for twelve months and have the whole process laid out for them.” While descriptions of more aligned grazing management demonstrated an adaptive capacity and a responsive approach to seasonal and market variation, grazing

management approaches of farmers in the less aligned cohort were conservative and/or more reactive than proactive (Table 2).

Table 2. Quotes representing the grazing management approaches of More Aligned and Less Aligned farmer cohorts.

	More Aligned Farmers
1	You can go out into a paddock and say, "There's this much there, the cows need this, we need to give them this area." I can just go out into a paddock, I can do that in my head now and actually know that I'm fully feeding my cows, within reason. [I'm] calculating and measuring the area a lot more.
2	I used to go out with the pasture meter and walk around the farm, and plug it all into the computer and it'd spit out an answer. I did a year of pasture metering, and then eyeballing from then on sort of thing. I learnt….that [taking measurements and using data are] a good guide but hey, stay out in the field and adapt to it out there.
3	I just know the requirements of the farm at any given time to say, "Right, we need to be growing 30kg a day to break even."….And so if I know that the farm's growing 60 I can see that we're only eating 50, I know we're growing 10 kilos a day that we can then put into silage…. And then you'd….work out how much area that would equate to.
4	If the cows haven't chewed it out they'll put the cows back in there….have breakfast and then move them into the next paddock. Depending on the time of the year depends on the allocation. So I'll say to them, "We want to be on a 60 day round, or a 30 day round". And I'd explain to the boys how to work that out….you need to give them 1.5 ha/day.
5	The farm apprentice usually does a weekly farm ride….[with a C-Dax]….We just sit down then and have a look at the cover and make a few decisions, and really I guess I put the plan together for the week….We've got a spreadsheet that just does a feed wedge. And I've got a bit of a report that...has the size of the paddocks, then the amount of feed available.
6	I really monitored and measured through that 20-12 Program [coaching extension] and followed on….until I got to a point where I was confident that I could eyeball it. And that probably took, a year and a half, or a season….I probably measure half a dozen times through the season [now], probably at the start of the season, the first round just check residuals a bit.
7	It's having that data about knowing how much grass you've got [that] makes it a lot easier to actually make that decision and know you need to spend that money….When you've got the information you sort of relax and you know where you are, whereas when you don't it's sort of a constant daily assessment to try and figure out where you're actually up to.

	Less Aligned Farmers
1	I haven't been looking at leaf stages, I've just been going, "Oh there's a decent amount of grass in there, we'll get in there."
2	We're not debt driven so we err on the side of being understocked….We use a lot of visual….But the plate meter….We're very aware we should do more measuring….
3	I'm probably a little bit late cutting silage because we sort of hold off that extra week or two, thinking, have we got enough? And then it's not as good a quality as it could have been.
4	I just eyeball it and see what I reckon is in the paddock, and if it was near enough….The stocking rate's not too high at the moment. I've got plenty of ground to cover the animals we've got.
5	The rotation is set [in summer] and I just add in silage. If I need to feed two bales, I feed two to get that two feeds out of a paddock...They do get a bit less some days and it affects the vat.
6	We've never been able to have the round….long enough here….You want to try and get it out to like 90 days, and we're struggling to probably get past 60.
7	It can make it hard sometimes and you feel like, "Oh gee I should be shifting them, but they haven't really cleaned it out."…. You know how far do you push a cow to make them eat it?

Farmers with reactive grazing management described issues associated with running out of feed and fluctuations in milk production. With little quantification of allocations to align with farmers' experience and observations, decision-making reacteing to cow behaviour, milk vat readings and appearance of pasture following allocations. Less Aligned Farmer 5 adjusts his/her next pasture allocation based on "how quick the cows rush into the dairy. If they're rushing into the dairy I know I didn't give them enough grass." This reactive approach indicates there is a gap in the knowledge and skills needed to translate awareness of ideal pasture cover and grazing residual numbers into confidently quantifying allocations. Less Aligned Farmer 1 explained, "there's no numbers in this at all, I just kind of go, well we've got this much area so I can give them this much grass…And then how much residual there is afterwards as they come out. If it's all gone am I not feeding them enough, can I give them a more? If I think I can I'll give them a bit more, if I can't then I have to give them a bit…of supplements." When the less aligned approach to grazing management was conservative it included low stocking rates and resulted in low quality silage due to delayed cutting.

Discussion

There are similarities in the awareness and practices of more aligned and less aligned grazing managers that may lead RD&E providers to believe both cohorts would benefit from the same research outputs and advisory support. A deeper exploration of the knowledge and skills underlying grazing management approaches revealed the confident, responsive approach of the more aligned cohort compared with the reactive and/or conservative approaches of the less aligned cohort. Decision making processes and issues resulting from different grazing management approaches were useful identifying features of more aligned and less aligned farmers. Less aligned grazing managers described a reactionary process to adjusting allocations based on observations of animal behaviour, milk vat readings and pasture appearance following grazing, with little quantification involved. While more aligned grazing managers also valued visual assessments and observations, they were incorporated in a confident, pro-active approach to setting rotation length and calculating allocations that was based on their knowledge of pasture availability and cow nutritional requirements.

All more aligned farmers had been through an intensive learning process that involved gaining an understanding of the biological principles underlying grazing management, regularly measuring pasture growth, carrying out mathematical calculations associated with allocations and developing new practical skills on-farm (e.g. how to apply leaf stage principles). However, these farmers now vary in the extent of their current pasture measurement and use of spreadsheets and feed wedges, with only 2 of the 7 more aligned cohort taking the more scientific approach to farming that is described by Eastwood and Kenny (2009). The remaining more aligned farmers demonstrated a more adaptive use of measuring and monitoring in their grazing management, and alternate between heuristic-based decision making and a more quantitative approach (Ohlmer *et al*. 1998).

The heuristic approach to grazing management was more effective for the more aligned grazing managers in this study than the less aligned, because there is 'unconscious incompetence' in play for the latter; a lack of knowledge and skills required to apply and adapt best practice recommendations. In contrast, more aligned farmers have the capacity to carry out informed heuristic decision making in their grazing management. They have proceeded through a learning process that has developed their competency (Robinson 1974), from unconscious incompetence to unconscious competence, with the capacity to independently adapt recommended practices and vary the extent of their quantification.

While farmers from both cohorts exhibited some similarities in awareness and practices, and demonstrated a heuristic approach to grazing management, their needs for support services differ. The role of extension for less aligned farmers is to provide intensive learning processes that involve consistent measuring and monitoring of pasture growth for a 12 month period, and ongoing support as farmers develop knowledge and skills to confidently and accurately set grazing rotations and allocations. Incorporating technical innovations that capture pasture growth data more efficiently than the traditional plate meter and C-Dax methods into this extension delivery would allow farmers and advisers to work together through any issues arising when interpreting and applying the data.

On-farm shared problem solving by farmers and those in advisory roles is as an essential component of the learning process required for adoption of knowledge-intensive practices (Turner and Irvine 2017). We suggest that providing any form of pasture biomass and growth rate data to less aligned farmers outside of a supported learning process, is unlikely to result in improved grazing management practices. Extension providers must also consider how to deliver this new technology to the potentially large proportion of more aligned dairy farmers who are not measuring pasture growth regularly or quantifying allocations tightly. As their current use of pasture growth data is limited, on-farm resources resulting from technological innovations that capture pasture growth data must be tailored to their current decision making processes, and proven benefits of consistent measuring and monitoring (Irvine and Turner 2018; Beukes *et al*. 2018) re-emphasized to industry.

Conclusion

This study adds to understanding of farmer learning processes and provides some rich insights into factors influencing potential use of pasture growth data made available through new technology. It reveals that provision of pasture growth data alone is insufficient for many grazing managers, and should be accompanied by a supported learning process to prompt practice change. The study's exploratory nature and small qualitative design means it is not representative of the full range of farmer motivations and complex social drivers influencing adoption of recommended pasture management practices. Further research is required to establish whether the findings are applicable to other dairy systems or can inform extension and adoption efforts for other commodities.

Conflict of interest

The authors declare no conflicts of interest.

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